VI. ANALYSIS OF WATER SUPPLY ALTERNATIVES

Ground water is the most significant source of the water supply for urban and agricultural demands in the LWC Planning Area, and it is anticipated that it will continue to be the most significant source of water for these needs in the foreseeable future. Both the continuously increasing demand for ground water as well as historical flood control and drainage practices have caused local and regional declines in ground water levels. Ground water declines are expected to increase in the future, due to the projected increases in ground water demands. A variety of adverse impacts may be associated with long-term declines in ground water levels. These adverse impacts can be separated into three generalized categories: (1) environmental resource impacts, (2) ground water resource impacts, and (3) geotechnical impacts.

Environmental resource impacts are generally caused by decreases in the amount and duration of water occurring at, or immediately below, the land surface. An example of this is a decrease in the seasonal inundation for a particular wetland system that leads to a change of species composition or distribution. Ground water resource impacts are those which result in a decrease in the quantity or quality of water available from an aquifer or aquifer system. Examples include seawater intrusion, movement of saline water into a freshwater zone, aquifer compaction, and decreased well yields. The geotechnical category includes impacts which may not harm the quantity or quality of water available from an aquifer, but are, nevertheless, significantly adverse. Examples of geotechnical impacts include regional land subsidence and local sinkhole formation. Physical changes to wells such as collapsed casing and/or screens, encrustation and/or air blockage of screens could also be placed in this category.

A five-step process was used to define criteria which when exceeded may result in adverse impacts as described above when applying these criteria to existing and future demand scenarios:

1. Identify potentially significant adverse impacts. The potential adverse impacts caused by ground water level drawdowns were identified. Adverse impacts which could be significant were identified for further analysis.

2. Determine levels of significance. This is an evaluation of those declines in water levels that may cause significantly adverse impacts. This step essentially requires the determination of thresholds at which the adverse impacts from water level declines are considered significant. This can be difficult. Often the relationship between water level declines and the resulting impacts may not truly be a threshold phenomenon. In other cases the threshold may not be known, or the frequency and duration of a drawdown may be more important than the amount of drawdown. Published research and the experience of various experts are used to assess significance, but determining a threshold of significance ultimately requires judgment.

3. Develop resource protection criteria. These criteria are essentially minimum ground water levels that were developed both for ongoing planning purposes and for future regulatory authority. Resource protection criteria for this plan were developed with consideration to all four of the principal elements of the SFWMD's mission, and are used in this plan in three ways: (1) to define excessive water-level decline in the context of this plan, (2) to identify where excessive declines might occur in the future using ground water flow models,

and (3) to assist in evaluating the effectiveness of alternative modeling scenarios in avoiding or mitigating the adverse impacts of excessive water-level declines.

4. Simulate water levels. Ground water flow models were used to predict water levels in the aquifers based on simulated conditions of rainfall and water demands in the year 2010.

5. Locate areas not meeting resource protection criteria. The simulated ground water levels produced by ground water flow models are compared to the resource protection levels to identify potential future problem areas. This step was accomplished utilizing a variety of tools including geographic information system software.

Based on the results of this five-step process, alternative modeling scenarios were developed and modeled to decrease the extent of areas which did not meet resource protection criteria. These scenarios included: (1) changes to projected water demands, (2) changes to new water sources, (3) changes to District operations, and (4) various combinations of these scenarios. The results of the alternative modeling scenarios were used to develop specific recommendations intended to minimize future adverse impacts. These recommendations are found in Chapters III and IV of the Planning Document.

RESOURCE PROTECTION CRITERIA

Three resource protection criteria were developed for analysis using ground water flow models. These criteria are standards to measure the level of protection of both wetlands and the ground water resources a number of adverse impacts caused by the pumping of ground water. The criteria include specific definitions of the severity, duration, and frequency of excessive declines in ground water levels.

Wetland Protection Criterion

The potential for impacts to natural systems as a result of ground- and surface-water withdrawals to meet future demands is of concern. Withdrawals can alter the natural hydrology by lowering ground- and surface-water levels and reducing hydroperiods. Hydrology is the single most important factor in determining the type of vegetation that occurs across the landscape. Fire frequency and soil type are additional important factors that are often closely related to hydrology. Man-induced alterations in hydrology can affect species composition and distribution as well as the functions and values of natural systems.

Current District rules are narrative in nature and do not clearly define what impacts are considered unacceptable to natural systems with regard to altering their hydrologic conditions. This narrative rule has been translated to a guideline that withdrawals must not lower the water table by more than one foot under a wetland after 90 days of maximum pumpage with no recharge. Development of better criteria in terms of severity/duration/frequency is needed to reflect the District's current understanding of natural system needs. This will be accomplished through a team approach using the departments of Research, Planning, and Regulation. The Research Department is working to define the requirements of natural systems. The Planning Department will bring forward the concepts and results of research through the planning process, to the public for review and input. The Regulation Department will then initiate rulemaking changes and implement the new rules on a day-to-day basis.

The specific wetland protection criteria identified the potential of impacts to wetland systems from future ground water withdrawals. The analysis used simulations of man-induced drawdowns of the water table aquifer for the year 2010. These simulations were generated by ground water flow models and were stated in terms of severity, duration and frequency of drawdowns. The projected water table aquifer drawdowns was then evaluated with respect to regional wetlands systems in the LWC Planning Area.

This analysis included an evaluation of current regulatory guidelines for drawdown under wetlands as well as evaluation of alternative guidelines. Variations on the future water use and withdrawal scenario were also incorporated into the analysis. Recommendations for specific wetland protection drawdown criteria were formulated and presented. The recommended criteria is based on the need to prevent significant harm to natural systems while providing adequate water to meet future demands.

Seawater Intrusion Criterion

This criterion applies to selected locations along the Gulf Coast in Lee and Collier counties based on evidence of historical seawater intrusion or upon geologic evidence of susceptibility to seawater intrusion at these locations. Minimum allowable ground water levels in the Intermediate and Surficial aquifer systems were chosen for these locations to prevent seawater intrusion except during more extreme drought events. The seawater intrusion criterion is generally defined as follows: Ground water levels should not decline below the criterion level for any period of time during any drought event that occurs more frequently than once every ten years.

General Aquifer Protection Criterion

The general aquifer protection criterion applies to all locations in the LWC Planning Area, and is based on the recognition that certain declines in ground water levels are potentially associated with a number of significant adverse impacts including reduced well yields, aquifer compaction, land subsidence, sinkhole formation, and brine migration. To prevent such impacts, minimum allowable ground water levels (criterion levels) are set at an elevation above the top of the aquifer. The distance from the top of the aquifer to the general aquifer protection criterion level is approximately the uncertainty associated with knowing where the top of the aquifer actually is. For example, if the top of the aquifer is estimated to be at an elevation of 50 feet below sea level with an uncertainty of 10 feet (i.e., -50 feet plus or minus 10 feet), then the criterion levels would be set at an elevation of 40 feet below sea level. The general aquifer protection criterion is defined as follows: Ground water levels should not decline below the criterion level for any period of time during any drought event that occurs more frequently than once every ten years.

MODELING ANALYSIS OF RESOURCE PROTECTION CRITERIA

Ground Water Modeling Approach

Ground water flow models were used in this plan to help evaluate excessive ground water declines during long-term average hydrologic conditions (steady-state conditions) and during short-term dry periods (transient conditions) when water demand is high and the supply, ultimately derived from precipitation, is low. The ground water simulation periods for short-term dry periods ranged from 12 to 24 months in duration. The dry periods were extracted from historical rainfall records for Collier, Hendry and Lee counties in tables C-2 through C-4 (Appendix C). These simulation periods were chosen because most droughts in South Florida are of two years duration or less. The models simulated ground water levels in response to current and future demands from the aquifers.

Three separate site-specific ground water models were developed by the SFWMD using generic computer code prepared by the U.S. Geological Survey (McDonald and Harbaugh, 1988) as well as site-specific information representing hydrologic conditions. The geographic areas represented by the models are shown in Figure VI-1. The models, although complex in many respects, are simplified representations of the real hydrologic systems and processes, and they incorporate certain assumptions concerning the physical characteristics and processes occurring in the real hydrologic systems. The hydrologic processes simulated by the ground water models included: (1) horizontal and vertical ground water flow in response to differences in water levels; (2) ground water recharge from precipitation; (3) flow to and from major rivers and ground water; (4) drainage from ground water to major canals and drains; (5) evapotranspiration; (6) return flow (deep percolation) of applied agricultural irrigation water; (7) ground water pumping for public water supply; and (8) ground water pumping for agriculture and other irrigated demands. The details of how these processes are simulated by the models can be found in other District publications (Bower *et al.*, 1990; Smith, 1990; Bennett, 1992).

Major aquifers occurring in the LWC Planning Area are represented as individual layers in the ground water models. Within each layer there is a grid of squares, or cells, each having an area of one square mile. Solutions to the various ground water flow model scenarios utilized for this plan yielded water levels that are representative of the entire volume of each cell.

The approach to modeling ground water conditions in the year 2010 involved the identification of a hypothetical set of conditions representing future water demands. This hypothetical set of conditions is collectively referred to as the base case for the purposes of this report. The hypothetical conditions, or assumptions, of the base case represent a view of the future if no additional water supply or water conservation measures are implemented beyond those which are currently mandated.

Demand Assumptions

The water supply for urban and agricultural demands are represented as withdrawals from specific layers of the ground water models. These demands have been summarized previously in Chapter IV of this volume. The categories of urban and agricultural water demand are combined somewhat differently for use in the model simulations than was presented in Chapter IV. In general, there are two categories of water demands used by the flow models: (1) seasonal water demands that vary by calendar month but which do not vary as a function of specified monthly

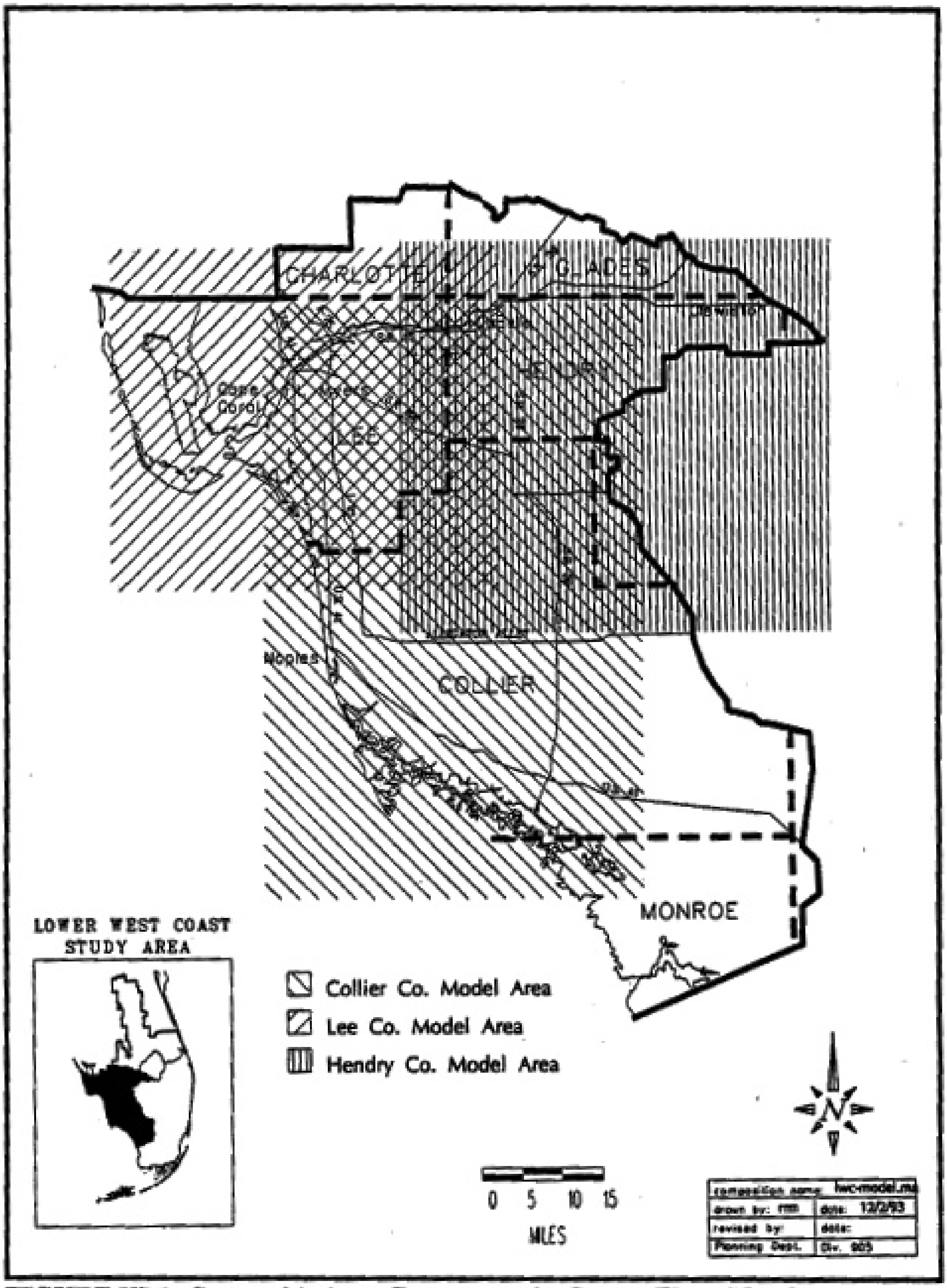

FIGURE VI-1. Geographic Areas Represented by Ground Water Models.

rainfall amounts, and (2) water demands that are explicitly dependent upon precipitation and that vary as a function of the specified monthly rainfall amounts. The first category generally includes public water supply provided both by utilities and individuals (domestic self supply). The second category includes all of the agricultural water demands as well as landscape and golf course irrigation.

Public Water Supply

The simulation of ground water pumping for public water supply was based on population estimates and per capita water consumption compiled from various information sources. Ground water pumping for public water supply was adjusted for seasonal variation in demand based on average values for calendar-month time periods. The per capita demands for water provided by utilities were adjusted downward for the year 2010 to reflect a number of mandatory and voluntary conservation measures, as described in Chapter V, that will be in place by 2010.

Agricultural Water Demands

The simulation of ground water pumping for agricultural water supply was based on crop acreage, crop type, and specified monthly rainfall amounts. The actual and projected irrigation demands presented in Chapter IV are based on historical crop acreage data, as discussed in Appendix G. These data were available on a county level, which lack the resolution to identify problem areas in the ground water model grids. Therefore permit data, which show the locations of permitted withdrawals, were used in the modeling process because these data have the level of resolution required by the ground water models. The permitted demand level for 1990 was used to represent the 1990 irrigation demands. To represent the 2010 demands, the projected demand data for 2010 were developed using the methodology described in Appendix G.

The 1990 permitted demand is considerably higher than the actual 1990 demand level presented in Chapter IV because considerably more agricultural acreage was permitted in 1990 than was actually planted. Actual crop acreages are usually less than the permitted acreage due to the lags between permitting and planting. The 2010 projected land use represents anticipated actual land use rather than forecast permitted land use.

Alternative Modeling Scenarios

A systematic, analytic process was followed in developing final recommendations for the Lower West Coast Water Supply Plan. The first step of this process involved applying the demand assumptions and resource protection criteria described above using the ground water models to arrive at 1990 and 2010 base case model results. The base case results were used as the constant, or measuring standard, when analyzing regional alternative modeling scenarios. The base case runs assumed no changes to the current methods of supplying water to the lower west coast; they simply portrayed what might occur if 1990 and 2010 water demand were applied against the resource protection criteria and all other conditions remained constant. Measurable results were counted in terms of wetland impacts, saltwater intrusion and aquifer protection criteria being exceeded.

Next, a series of regional alternative modeling scenarios were developed and analyzed using the ground water models. The results of the alternative model scenarios were compared to the base case model results using the following measures:

(1) The total area of wetlands (in acres) in which wetland criteria were not met.

(2) The number of coastal model cells in which seawater intrusion criteria were not met and the number of months during a simulation when these model cells did not meet the criteria.

(3) The number of model cells in which seawater intrusion criteria were not met and the number of months during a simulation when these model cells did not meet the criteria.

The following model scenarios were simulated for this plan:

Scenario 1 - Remove public water supply demands from the shallow aquifers. Two variations on this model scenario were simulated for both Collier and Lee counties. Public water supply demand is a relatively small component of the total demand in Hendry County, so scenario 1 was not simulated for Hendry County. All public water supply withdrawals were removed from the shallow aquifers in scenario 1a. This scenario eliminated any problems in not meeting the resource protection criteria due to public water supply withdrawals. In scenario 1b, the increase in public water supply withdrawals between the 1990 permitted demand level and 2010 projected demand level was removed from the shallow aquifers. Scenario 1b isolates the effect of the increased public water supply demand with respect to meeting the resource protection criteria. Although both modeling scenarios 1a and 1b remove the public water supply demand from the shallow aquifers, neither scenario specifies nor simulates an alternative source for these demands. The most probable alternative source for these demands is the Floridan aquifer system; however, simulation of flow in the Floridan cannot be done with the existing models.

Scenario 2 - Reduce agricultural water use by increased irrigation efficiency. Three variations of this modeling scenario were simulated. In scenario 2a, the irrigation efficiency for small vegetable crops was increased to 75 percent for all users currently below that efficiency level. In scenario 2b, the irrigation efficiency for citrus was increased to 85 percent for all users currently below that level. Scenario 2c was a combination of scenarios 2a and 2b. All three model scenarios were simulated by reducing irrigation withdrawals for small vegetable and/or citrus crops in the model runs.

Scenario 3 - Increase use of reclaimed water. The total amount of reclaimed water available for irrigation was assumed to be the average of the three minimum flow months for each regional wastewater treatment plant in the LWC Planning Area for 2010. Wastewater flows exceeding the simulated irrigation requirements and flows for which an application area could not be defined were assigned to the treatment plant's alternative disposal source and/or to demands not incorporated in the model. This scenario was simulated by reducing well withdrawals and replacing them with reclaimed water.

Scenario 4 - Implement proposed long-term modifications of the Big Cypress Basin canal system. Modifications to this canal system included elimination of canals in the South Golden Gate Estates area and addition of control structures on the Miller and Faka Union canals directly north of Alligator Alley. Control elevations for the new structures were set at one foot below land surface to maintain higher water levels north of I-75. This scenario is specific to Collier County and was simulated with the Collier County model by adjusting the simulated canal levels accordingly. The proposed modifications to the Big Cypress canal system include facilities for backpumping water to the north Golden Gate Estates area and other routing of surface water through the canals; however, these modifications cannot be fully represented in the ground water model. A watershed management plan will be developed by the Big Cypress Basin Board within the next year. This watershed management plan should be able to provide more detailed evaluations of the benefits of the proposed modifications.

Scenario 5 - Combination of Scenarios 1 and 3. This scenario has two variations. Scenario 5a combines scenario 1a, in which all water supply withdrawals were removed from the shallow aquifers, with scenario 3, in which irrigation withdrawals were partially replaced by reclaimed water. Scenario 5b combines scenario 1b, in which the increase in public water supply withdrawals between 1990 and 2010 were removed from the shallow aquifers, with scenario 3.

Scenario 6 - Evaluate combination of Scenarios 1, 2c, and 3. Modeling scenario 6 had two variations: (1) scenario 6a, which combined modeling scenario 1a (remove all public water supply from the shallow aquifers), modeling scenario 2c (improving the irrigation efficiency of both small vegetables and citrus), and modeling scenario 3 (increase use of reclaimed water); and (2) scenario 6b, which combined modeling scenario 1b (remove **future** public water supplies from the shallow aquifers), modeling scenario 2c, and modeling scenario 3. Modeling scenarios 1a, 1b, and 3 involved urban water supplies and reclaimed water, neither of which are very large in Hendry County. Scenarios 1a, 1b, and 3 were not simulated for Hendry County. Similarly, modeling scenarios 6a and 6b were not modeled for Hendry County.

The results of the scenario analyses described above are presented in Chapter II of the Planning Document.